Green Transition in Indonesia's Energy Sector: Environmental Performance, Corporate Governance, and Carbon Disclosure

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Abstract

This study examines whether environmental performance and selected good corporate governance mechanisms are associated with carbon emission disclosure among Indonesian energy sector companies during the green-transition period. Secondary data were obtained from the annual and sustainability reports of 19 energy companies listed on the Indonesia Stock Exchange that consistently participated in PROPER from to 2021-2024. Carbon emission disclosure was measured using the 18-item checklist. Environmental performance was measured using PROPER scores. Managerial ownership, institutional ownership, and audit committee size represented governance. Firm size was included as a control variable. Multiple linear regression was performed using SPSS 31. After positive autocorrelation was detected, the source study applied a Cochrane-Orcutt transformation, reducing the 76 initial firm-year observations to 75. Environmental performance was positively and significantly associated with carbon disclosure ($B=0.140$, $p<0.001$). Managerial ownership and audit committee size are not significant, while institutional ownership is negatively associated with disclosure ($B=-0.214$, $p=0.026$), contrary to the hypothesized positive direction. The overall model was significant, $F(5,69)=5.445$, $p<0.001$, with an adjusted R^2 of 0.231. Carbon transparency in the sampled energy firms is more consistently related to observable environmental performance than to the formal governance mechanisms examined in this study. The study covers 19 listed energy firms over four years and does not estimate firm-specific panel effects. This study distinguishes statistical significance from directional hypothesis support and highlights the need for more refined governance measures in carbon disclosure research.

Keywords: *Carbon Emission Disclosure, Energy Sector, Environmental Performance, Good Corporate Governance, Institutional Ownership*

1. INTRODUCTION

Climate change has intensified the pressure on governments and corporations to make greenhouse gas impacts visible, measurable, and accountable. Indonesia faces a particularly important challenge because energy production and use remain major sources of national greenhouse gas emissions. Official statistics show that energy sector emissions increased from approximately 584.3 million tCO_2e in 2020 to 752.3 million tCO_2e in 2023, while Indonesia's Enhanced Nationally Determined Contribution commits the country to substantially reduce emissions by 2030 (Badan Pusat Statistik, 2024; Republic of Indonesia, 2022). For energy companies, the transition toward a lower-carbon economy concerns not only operational change but also the credibility and completeness of environmental information disclosed to investors, regulators, creditors, and the public. This transition creates a dual accountability requirement. Firms must demonstrate that they are managing environmental impacts and provide information that allows stakeholders to evaluate whether the reported actions are substantive, comparable, and consistent over time.

Carbon Emission Disclosure (CED) is one of the most direct forms of corporate climate transparency in China. It communicates the risks and opportunities associated with climate change, greenhouse gas measurements, energy use, emission reduction initiatives, and governance accountability. The widely used 18-item framework developed by Choi et al. (2013) enables empirical research to compare the breadth of corporate carbon information using content analysis. Recent evidence shows that carbon disclosure is shaped by environmental performance, governance, ownership, media exposure, firm characteristics, and the institutional context in which companies operate (Velte et al., 2020; Lu & Wang, 2021; Riswanda & Trisnawati, 2025; Anggreni & Budiasih,

2026). These determinants are not necessarily interchangeable with each other. Environmental performance reflects what a company has achieved, whereas governance variables describe the incentives and oversight arrangements that may influence the company's choice of reporting. Treating them as the same type of explanation can obscure whether disclosure follows actual environmental achievements, formal governance design, or both.

The Indonesian energy sector provides a relevant setting because its firms operate under high environmental visibility while simultaneously facing capital-intensive investment requirements and transition risk. Carbon disclosure can function as a legitimacy mechanism when companies seek to demonstrate that their environmental practices are consistent with the social expectations. It can also function as a stakeholder information mechanism because investors and other users increasingly require evidence of emissions, transition plans, and environmental accountability. Prior Indonesian studies have found that environmental performance can be associated with broader CED, although the findings remain inconsistent across periods, sectors, and measurement choices (Amaliyah & Solikhah, 2019; Loru, 2023; Purnayudha & Hadiprajitno, 2022; Fazrin et al., 2025; Putri & Wirakusuma, 2025). Loru (2023) and Purnayudha and Hadiprajitno (2022) provide evidence that environmental performance can strengthen disclosure, whereas Amaliyah and Solikhah (2019) and Riswanda and Trisnawati (2025) show that this relationship is not uniform across samples and operational definitions. More recent evidence also indicates that carbon disclosure may be connected to firm value, media exposure, and broader environmental variables rather than environmental ratings alone (Fazrin et al., 2025; Putri & Wirakusuma, 2025; Melinda & Dewi, 2026). This comparison suggests that the empirical gap is not simply the absence of research on the topic. The unresolved issue is why the same broad construct produces different results across Indonesian settings and whether the results change when environmental performance and governance mechanisms are examined together in a highly visible sector.

Good Corporate Governance (GCG) is another potential driver of climate transparency because ownership and oversight structures can affect managerial incentives and the demand for nonfinancial information. International evidence links governance quality, climate oversight, and board structures to stronger environmental or carbon disclosure (Kılıç & Kuzey, 2019; Bui et al., 2020; Lu & Wang, 2021). Kılıç and Kuzey (2019) show that governance characteristics can influence the extent of carbon disclosure, while Bui et al. (2020) emphasize the importance of climate governance for disclosure and environmental performance. Lu and Wang (2021) further indicate that the relationship between governance and environmental disclosure is conditioned by the legal, cultural, and institutional environments. This implies that a governance mechanism cannot be assumed to have the same effect in every country or industry. In Indonesia, the governance mechanisms do not produce uniform results. Managerial ownership is sometimes expected to align management with a longer-term corporate reputation, institutional ownership may strengthen external monitoring, and audit committees may improve reporting oversight. However, empirical studies have shown that these mechanisms can be insignificant, context-dependent, or operate differently from their theoretical predictions (Simamora et al., 2022; Fuadah et al., 2022; Suherman & Kurniawati, 2023; Yasa & Sudana, 2025).

This inconsistency is important for energy sector firms. For example, high institutional ownership does not automatically imply greater pressure for detailed carbon disclosure if institutional investors prioritize financial resilience, cash flow, or transition investment over the breadth of voluntary reporting. Similarly, the number of audit committee members may be a weak proxy for actual sustainability oversight when committee expertise, meeting intensity, independence, or climate-specific responsibilities are not observed. Recent Indonesian studies increasingly use more detailed governance and environmental variables, indicating that the quality of the mechanism may matter as much as its formal presence (Afnilia & Astuti, 2023; Blesia et al., 2023; Febrianto et al., 2022; Aprilia et al., 2026). Therefore, the research gap has three connected dimensions. First, prior findings are inconsistent regarding whether environmental performance and governance increase CED. Second, many studies discuss the variables separately, making it difficult to compare observable environmental outcomes with formal ownership and oversight structures within one model. Third, the period

2021-2024 represents a distinctive green-transition setting in which energy firms face simultaneous pressure from emissions reduction, investor scrutiny, transition financing, and expanding sustainability-reporting expectations. Results from earlier periods or mixed-sector samples may not adequately capture these pressures. Therefore, a focused examination of Indonesian energy companies can clarify whether public carbon transparency is more closely associated with demonstrated environmental performance or with the formal governance mechanisms surrounding corporate decision-making.

This study addresses this issue by examining environmental performance and three GCG mechanisms–managerial ownership, institutional ownership, and audit committee size–while controlling for firm size. The setting covers energy companies listed on the Indonesia Stock Exchange (IDX) during 2021-2024, a period characterized by growing climate policy attention and expanded sustainability reporting. Environmental performance is represented by the Indonesian Program for Pollution Control, Evaluation, and Rating **(**PROPER) rating, and CED is derived from annual and sustainability reports using the Choi et al. (2013) checklist. The combined design is important because it places outcome-oriented environmental measures and structure-oriented governance measures in the same empirical comparison. It also keeps the period, sector, and disclosure index consistent across analyses, reducing the risk that differences in sampling or measurement alone explain the observed relationships. This study does not assume that a significant coefficient automatically confirms a hypothesis. Instead, it distinguishes the existence of an association from an agreement with the predicted direction.

This study contributes to the literature in three ways. First, it focuses specifically on the disclosure dimension of the green transition, rather than treating sustainability reporting as a broad aggregate construct. Second, it evaluates environmental performance and governance in the same model, enabling a comparison between observable environmental outcome signals and ownership or oversight mechanisms. Third, it reports the direction of institutional ownership transparently. A statistically significant negative coefficient is interpreted as evidence against the hypothesized positive relationship rather than being presented as simple evidence. This distinction is important because significance and directional hypothesis support are not equivalent. In addition, this study contributes a context-sensitive interpretation of governance. It examines whether formal governance structures are measurably associated with carbon transparency when firms operate in an emission-intensive industry and during a period of accelerated transition. This approach responds to international evidence that climate-specific oversight and institutional contexts may matter more than generic governance labels (Bui et al., 2020; Lu & Wang, 2021).

Therefore, the research question is whether environmental performance, managerial ownership, institutional ownership, and audit committee size are individually associated with carbon emission disclosure and whether the model is jointly significant after controlling for firm size. The analysis also evaluates how the findings relate to legitimacy and stakeholder theory and to recent carbon disclosure evidence in Indonesia and other emerging market settings (Suryani & Wijayati, 2019; Setiawan et al., 2022; Melinda & Dewi, 2026). Specifically, this study seeks to determine whether a company with stronger observable environmental performance discloses more carbon information, whether ownership structures provide incentives for broader disclosure, and whether the size of the audit committee represents sufficient oversight capacity. By addressing these questions in one energy sector sample, this study clarifies the boundary conditions of the positive-monitoring argument and identifies where the formal presence of a governance mechanism may be too broad to explain climate transparency.

2. LITERATURE REVIEW

Legitimacy theory provides a theoretical foundation. Organizations depend on social acceptance, and a legitimacy gap may emerge when corporate actions or impacts are perceived to conflict with social expectations. Dowling and Pfeffer (1975) describe legitimacy as congruence between organizational activity and the values of the broader social system. In the climate context, disclosure can be used to explain environmental impacts, communicate corrective actions, and

demonstrate alignment with evolving expectations. Carbon reporting is especially relevant for energy companies because their emissions exposure makes the environmental consequences of their operations highly visible (Susi & Rayyani, 2026). This theory implies a causal mechanism from environmental performance to disclosure. Companies that achieve stronger PROPER ratings have more credible evidence to demonstrate alignment with environmental expectations. Publicizing performance can narrow the legitimacy gap, protect the organizational reputation, and show that environmental claims are supported by observable actions (Priyanti & Dewi, 2026). The same mechanism also creates an incentive for firms with weaker performance to disclose remedial initiatives. However, disclosure may be less comprehensive or credible when it is not accompanied by measurable outcomes. Therefore, the positive hypothesis represents the expected average relationship between credible environmental achievement and the breadth of carbon information, not the assumption that poor-performing firms never disclose.

Stakeholder theory provides a complementary perspective. Freeman (1984) argues that firms must consider parties that can affect or are affected by their corporate activities. Carbon information serves multiple stakeholder groups. Investors assess transition risk, regulators monitor environmental accountability, creditors consider long-term exposure, and communities evaluate the environmental consequences of operations. This implies that governance mechanisms can affect disclosure when they strengthen monitoring or increase management's incentives to respond to stakeholder information demands. Therefore, the causal pathway is indirect but identifiable (Khasanova, 2025; Mohsin, 2026). Ownership and oversight arrangements influence who receives information, how strongly management is monitored, and whether environmental issues are considered in strategic decision-making. If influential stakeholders demand comparable emissions information, an effective governance structure should make it difficult to ignore such demands (Ahmadi, Yuniarti, & Puspitasari, 2024). International research supports this view. Governance quality and climate oversight are associated with environmental disclosure when they create real accountability channels. However, generic structures may be less informative when they do not include climate expertise or explicit reporting responsibilities (Kılıç, & Kuzey, 2019; Bui, Houqe, & Zaman, 2020; Mardalena, Fachrudin, & Indrawan, 2026). Thus, stakeholder theory supports the hypotheses while explaining why formal governance measures may show weak or heterogeneous empirical effects.

Environmental performance captures the extent to which a company demonstrates effective environmental management. In this study, it is proxied by PROPER, which ranks corporate environmental performance from black to gold (Priyanti & Dewi, 2026). Legitimacy theory predicts that firms with stronger environmental performance have greater ability and stronger incentives to publicize their environmental achievements. This mechanism operates through information credibility and organizational visibility. A high PROPER rating gives management a favorable environmental outcome to communicate, whereas a low rating can increase reputational risk and limit the value of selective disclosure. Empirical evidence is consistent with this argument in several Indonesian contexts. Loru (2023) reported a significant effect of environmental performance on the CED. Purnayudha and Hadiprajitno (2022) identified environmental performance as an important determinant of firm value. More recent studies continue to report positive relationships in selected samples (Putri, & Wirakusuma, 2025; Melinda, & Dewi, 2026; Aprilia, Wahyuni, Hariyanto, & Azizah, 2026). However, other studies find weak or insignificant effects, indicating that sector, period, and measurement remain important (Amaliyah, & Solikhah, 2019; Riswanda, & Trisnawati, 2025). International evidence also suggests that environmental performance and disclosure should be interpreted together because disclosure may be informative only when it corresponds with actual performance (Velte, Stawinoga, & Lueg, 2020; Lu, & Wang, 2021). Overall, companies with better PROPER performance are expected to disclose more carbon information. Accordingly, the following hypothesis is proposed:

H_1: Environmental performance is positively associated with carbon emissions disclosure.

Managerial ownership represents the proportion of outstanding shares held by the management. From a governance perspective, managerial shareholding may align decision-makers with the firm's

long-term value and reputation. If managers internalize more of the consequences of environmental controversy, they may favor broader disclosure to reduce information asymmetry and signal responsible management. The proposed causal mechanism is an alignment process. Equity ownership increases the portion of firm value that managers personally bear, which can reduce the incentive to conceal environmental risks and increase attention to reputation, financing conditions, and stakeholder trust. Nevertheless, the same mechanism may weaken when ownership is very small or may become entrenched when managers hold sufficient control to resist external monitoring. The empirical findings are mixed. Simamora, Safrida, and Elviani (2022) found that managerial ownership is not a significant determinant of carbon disclosure in Indonesian mining firms, while other governance studies suggest that ownership effects depend on the magnitude and type of ownership rather than ownership presence alone (Fuadah, Mukhtaruddin, Andriana, & Arisman, 2022). International governance evidence also cautions that ownership is not a complete measure of climate oversight because the effect depends on whether owners actively engage with environmental information and whether managers face credible accountability (Velte et al., 2020; Lu and Wang, 2021). The source study follows the alignment argument and proposes a positive relationship between the two. Accordingly, the following hypothesis is proposed:

H_2: Managerial ownership is positively associated with the disclosure of carbon emissions.

Institutional ownership reflects the proportion of shares held by institutional investors. Institutional investors have resources, analytical capacity, and voting influence that strengthen the monitoring of management. Therefore, stakeholder and governance perspectives suggest that higher institutional ownership can increase the pressure for transparent environmental information. The proposed mechanism is that institutional monitoring raises the expected cost of withholding material climate information and encourages management to provide a more complete disclosure. However, this expectation is not universal. Putri, Pamungkas, and Suryaningsum (2022) reported no significant effect of institutional ownership on CED in a different Indonesian sample, while recent work highlights that institutional ownership may interact with other firm characteristics rather than directly increasing disclosure (Melinda & Dewi, 2026). Research on ESG and ownership also shows that ownership categories can have different consequences for disclosure and performance (Fuadah et al., 2022). International evidence indicates that investor influence depends on the investment horizon, sustainability preferences, ownership type, and the availability of private engagement channels (Velte et al., 2020; Lu and Wang, 2021). Therefore, a high aggregate percentage can combine active long-term investors with institutions that prioritize short-term financial outcomes or rely on private information. Nevertheless, the proposed directional hypothesis follows the monitoring argument. Accordingly, the following hypothesis is proposed:

H_3: Institutional ownership is positively associated with carbon emission disclosure.

The audit committee supports the board's oversight of reporting quality, internal control, compliance, and risk. A larger committee may provide greater monitoring capacity. However, size alone does not necessarily capture expertise or attention to sustainability. The causal mechanism assumes that additional members increase the committee's ability to review environmental information, challenge management's reporting choices, and connect non-financial disclosures with risk oversight (Safa & Arsjah, 2025). This mechanism is weak if the additional members do not possess relevant expertise, independence, meeting time, or authority. Simamora et al. (2022) reported a positive role for audit committees in carbon disclosure, whereas other Indonesian studies showed insignificant or context-dependent effects. Suherman and Kurniawati (2023) examine audit committees together with environmental and ownership variables, while Yasa and Sudana (2025) find that governance mechanisms can contribute to carbon disclosure in the energy sector. Broader governance evidence indicates that climate-specific oversight may be more informative than traditional governance structures (Bui et al., 2020). Consistent with the oversight argument, this study predicts a positive relationship. Accordingly, the following hypothesis is proposed:

H_4: Audit committee size is positively associated with carbon emission disclosure.

The four explanatory variables capture the different dimensions of corporate accountability. Environmental performance reflects a realized environmental signal, managerial and institutional ownership represents incentive and monitoring structures, and the audit committee represents formal oversight. Firm size is added as a control variable because larger firms typically face greater public visibility and possess more resources for sustainability reporting. Previous carbon disclosure research has repeatedly identified firm size, environmental performance, and governance as relevant determinants, although their individual effects vary (Velte et al., 2020; Suryani, & Wijayati, 2019; Zada, & Sari, 2024; Anggreni, & Budiasih, 2026). The integrated argument is that CED should be broader when firms achieve stronger environmental outcomes and face governance arrangements that demand credible communication of those outcomes. However, the quality of the mechanism may be more important than its formal presence. This explains why the model tests the variables together and why insignificant governance coefficients should not be interpreted as proof that governance is irrelevant. Consistent with the source thesis, the simultaneous hypothesis concerns the substantive environmental performance and GCG variables, while firm size remains a control. Accordingly, the following hypothesis is proposed:

H_5: Environmental performance and good corporate governance mechanisms are jointly associated with carbon emission disclosure.

3. RESEARCH METHODOLOGY

This study used a quantitative explanatory design with secondary data. The population comprises energy sector companies listed on the IDX from to 2021-2024. Purposive sampling was applied because the analysis required firms that were listed throughout the observation period, published annual and sustainability reports consecutively, and consistently participated in the PROPER environmental rating program.

Table 1. Sample-selection process

Criterion	Number
Energy-sector companies listed on IDX, 2021-2024	91
Excluded: incomplete consecutive annual or sustainability reports	(36)
Excluded: inconsistent PROPER participation, 2021-2024	(36)
Companies meeting all criteria	19
Initial firm-year observations (19 × 4 years)	76

As summarized in Table 1, the initial screening began with 91 energy-sector firms. Of these, 36 were excluded because the required annual or sustainability reports were not continuously available, and another 36 did not meet the consistent PROPER-participation criterion. Nineteen firms remained, producing 76 firm-year observations before the lag-based Cochrane-Orcutt transformation used in the source thesis. Although the observations have a firm-year structure, the source study estimated a pooled linear relationship rather than a fixed-effects or random-effects panel model. This distinction is important because the selected procedure is designed to address the serial correlation problem detected in the pooled regression, not to provide a complete model of unobserved firm-specific differences.

Data were obtained from annual and sustainability reports published on the IDX and company websites. Carbon disclosure was coded from public reports rather than self-reported survey responses. Environmental performance and governance variables were compiled for the same company-year observations. The source thesis reports data preparation in Microsoft Excel and statistical analysis using IBM SPSS Statistics 31. The firm-year format makes the dataset similar to a short panel, but its short time dimension and the source study's statistical workflow led to the use of multiple linear regression with a correction for detected serial correlation. Ordinary pooled regression is useful for estimating the average association across observed firm-years, but it has important limitations for longitudinal data. In particular, it may not remove time-invariant firm characteristics, may treat repeated observations as more independent than they actually are, and may leave results sensitive to

the ordering and dependence of the observations. These limitations should be considered when interpreting the findings. Therefore, the estimates are presented as sample-specific associations rather than definitive causal effects.

CED is the dependent variable. It is measured using the 18-item checklist introduced by Choi et al. (2013), covering climate change risks and opportunities, greenhouse gas emissions, energy consumption, greenhouse gas reduction and cost, and carbon accountability. Each item receives a score of one when it is disclosed and zero otherwise. The CED index is the number of disclosed items divided by 18, producing a score between zero and one.

Table 2. Variable operationalization

Variable	Measurement
Carbon Emission Disclosure (CED)	Disclosed Choi et al. (2013) items / 18
Environmental Performance (EP)	PROPER score: black=1, red=2, blue=3, green=4, gold=5
Managerial Ownership (MO)	Managerial shares / outstanding shares
Institutional Ownership (IO)	Institutional shares / outstanding shares
Audit Committee (AC)	Number of audit-committee members
Firm Size (SIZE)	Natural logarithm of total assets

Table 2 summarize the sample selection process and variable operationalization, respectively. Environmental Performance (EP) was measured using PROPER ratings, which were converted to an ordinal score, namely black=1, red=2, blue=3, green=4, and gold=5. Managerial Ownership (MO) is calculated as managerial shares divided by the total outstanding shares. Institutional Ownership (IO) is the number of institutional shares divided by the total outstanding shares. Audit Committee (AC) is measured by the number of audit committee members. Firm Size (SIZE) is measured as the natural logarithm of total assets. These operational choices follow the source thesis and are consistent with the common approaches used in Indonesian carbon disclosure research (Afnilia & Astuti, 2023; Putri et al., 2022; Zada & Sari, 2024).

The analysis was conducted using descriptive statistics and classical regression diagnostics. Residual normality was assessed using the one-sample Kolmogorov-Smirnov test. Multicollinearity was evaluated using tolerance and Variance Inflation Factors (VIF), while heteroscedasticity was assessed using Spearman correlations between each predictor and the unstandardized residual. Autocorrelation was examined using the Durbin-Watson (DW) statistic. The initial model produced a positive autocorrelation (DW=1.100). Therefore, the source study applied a Cochrane-Orcutt transformation. The methodological justification is that the transformation directly addresses a first-order serial correlation problem in the pooled regression residuals by estimating an autocorrelation parameter and transforming the variables before re-estimation. It was selected within the source thesis workflow because the diagnostic problem was explicitly detected in the Ordinary Least Squares (OLS) type model, and the objective was to correct that problem while retaining the stated linear specification. A panel estimator can provide a stronger treatment of repeated firm observations by modeling firm-specific effects and, where appropriate, year effects. However, Cochrane-Orcutt is not equivalent to fixed-effects or random-effects estimation and should not be presented as a substitute for these approaches. Because lagging removes the first usable observation in the transformed sequence, the final regression contains 75 observations, as confirmed by the Analysis of Variance (ANOVA) degrees of freedom (total *df*=74). The corrected model reported DW=1.877. The final regression specification after the Cochrane–Orcutt transformation is expressed as follows Formula 1:

$$\alpha + \beta 1EP + \beta 2MO + \beta 3IO + \beta 4AC + \beta 5SIZE + \varepsilon \quad (1)$$

Where CED represents Carbon Emissions Disclosure, EP represents Environmental Performance, MO represents Managerial Ownership, IO represents Institutional Ownership, AC

represents Audit Committee size, SIZE represents Firm Size, α is the constant, β_1–β_5 are the regression coefficients, and ε is the error term.

Partial t-tests were used to evaluate H_1-H_4. The overall F-test evaluates the joint significance of the full regression model, which includes firm size as a control. Therefore, it is interpreted as model-level evidence related to H_5 rather than as a separate partial F-test of the four substantive predictors alone. Statistical significance was interpreted at 5%, and directional hypotheses were considered supported only when significance and coefficient direction were both consistent with the hypothesis. The use of ordinary regression also means that the results should be read with caution because the transformation addresses serial correlation but does not fully resolve unobserved heterogeneity across firms or common shocks across the years.

4. RESULTS AND DISCUSSION

Table 3. Descriptive statistics

Variable	N	Min	Max	Mean	SD
CED	76	0.111111	0.944444	0.673246	0.205674
Environmental Performance (EP)	76	2	5	3.55	0.719
Managerial Ownership (MO)	76	0.000000	0.675614	0.061971	0.153474
Institutional Ownership (IO)	76	0.018868	0.948036	0.674219	0.271454
Audit Committee (AC)	76	3	5	3.41	0.696
Firm Size (ln assets)	76	20.712266	32.757800	29.598402	3.141271

As shown in Table 3, the 76 initial observations show meaningful variations in carbon disclosure and ownership structure. The CED index ranges from 0.111111 to 0.944444, with a mean of 0.673246, indicating that the average firm-year disclosed approximately 67.3% of the 18 checklist items. EP ranges from PROPER score 2 to 5 and averages 3.55, suggesting that most sampled company-years were concentrated around blue-to-green environmental ratings. MO is relatively low on average (6.2%) and highly dispersed, whereas IO is much higher, averaging 67.4%. AC membership ranges from three to five, which limits cross-sectional variation in the committee size proxy.

Table 4. Regression diagnostics

Diagnostic	Result	Interpretation
Residual normality	K-S p=.087	Normality not rejected
Multicollinearity	VIF=1.204-1.638	No material multicollinearity
Heteroskedasticity	Spearman residual p=0.097-0.965	No predictor-residual correlation significant at 5%
Initial autocorrelation	DW=1.100	Positive autocorrelation detected
After Cochrane-Orcutt	DW=1.877	Autocorrelation corrected under thesis criterion
Final transformed N	75	One observation lost through lag transformation

As summarized in Table 4, the diagnostic results show that the initial residual distribution does not reject normality (Kolmogorov-Smirnov p=.087). The VIF values ranged from 1.204 to 1.638, well below the commonly used thresholds, and the residual-correlation significance values used in the source study's Spearman heteroskedasticity test ranged from 0.097 to 0.965. The main diagnostic issue is serial correlation: the initial DW statistic of 1.100 is below the lower bound reported in this thesis. After the Cochrane-Orcutt correction, DW increases to 1.877, which the source study interprets as falling within the no-autocorrelation interval. This correction changes the analytical sample from 76 initial firm-year observations to 75 transformed ones.

Table 5. Multiple regression and partial hypothesis tests after Cochrane-Orcutt transformation

Variable	*B*	SE	*β*	*t*	*p*	Decision
Constant	0.041	0.159	-	0.258	0.797	-
Environmental Performance (EP)	0.140	0.035	0.438	4.022	<0.001	H_1 supported
Managerial Ownership (MO)	-0.261	0.192	-0.165	-1.361	0.178	H_2 not supported
Institutional Ownership (IO)	-0.214	0.094	-0.270	-2.281	0.026	H_3 rejected (opposite direction)
Audit Committee (AC)	-0.009	0.045	-0.026	-0.201	0.841	H_4 not supported
Firm Size	0.010	0.009	0.124	1.115	0.269	Control: not significant

Table 5 presents the final transformed regression and partial hypothesis test results. EP was positive and significant (B=0.140, β=0.438, t=4.022, p<0.001), supporting H_1. MO is negative but not significant (B=-0.261, p=.178), so H_2 is not supported. IO is negative and significant (B=-0.214, β=-0.270, t=-2.281, p=0.026). Because H_3 predicted a positive association, the statistically significant negative result rejects rather than supports H_3. AC size is not significant (B=-0.009, p=0.841). Therefore, H_4 is not supported. Firm Size, included as a control, was also not significant (B=0.010, p=0.269).

Table 6. Model fit and simultaneous test

Statistic	Value
R	0.532
R^2	0.283
Adjusted R^2	0.231
Std. error of estimate	0.15829
Durbin-Watson	1.877
F(5,69)	5.445
p-value	<0.001
Final N	75

As summarized in Table 6, the final model was jointly significant, F(5,69)=5.445, p<0.001, with R=0.532, R^2=0.283, and adjusted R^2=.231. The significant F statistic shows that the full model including EP, the three GCG variables, and firm size as a control provides joint explanatory information on CED. This result is consistent with H_5 at the model level, but it should not be interpreted as an isolated test of the four substantive predictors because the control variable was included in the same F test. The adjusted R^2 further indicates that most of the variation in disclosure remains outside the model. This is substantively plausible because carbon transparency can also reflect carbon intensity, profitability, media scrutiny, sustainability assurance, board expertise, green investment, regulatory exposure, and internal climate governance processes (Velte et al., 2020; Bui et al., 2020; Riswanda & Trisnawati, 2025; Anggreni & Budiasih, 2026).

EP had the strongest standardized association in the final model. The positive coefficient indicates that firms with better PROPER ratings tend to disclose broader carbon-emission information. This finding is consistent with legitimacy theory, which suggests that companies seek to maintain social acceptance by aligning their activities and disclosures with societal expectations. Companies that can point to stronger environmental outcomes have credible and positive information to communicate and may use disclosure to reinforce social acceptance. This is also compatible with stakeholder theory because better-performing firms can respond to external information demands with more concrete environmental evidence. This result aligns with evidence that environmental performance can increase carbon disclosure in Indonesia (Loru, 2023; Purnayudha & Hadiprajitno, 2022; Putri & Wirakusuma, 2025; Melinda & Dewi, 2026) and with international evidence linking environmental performance and broader corporate disclosure (Lu & Wang, 2021). This contrasts with studies that find environmental performance insignificant, underscoring that industry visibility and the 2021-2024 transition context may matter (Amaliyah & Solikhah, 2019; Riswanda & Trisnawati, 2025).

MO is not significantly associated with CED. The mean managerial shareholding is only approximately 6.2%, and many observations have zero managerial ownership. This distribution helps explain why the alignment mechanism may be too weak to materially alter the disclosure policy. Carbon reporting in energy companies may instead be determined by corporate reporting systems, regulatory expectations, sustainability functions, and board-level decisions that are not directly linked to managerial equity stakes. This finding is consistent with Simamora et al. (2022), who also reported an insignificant managerial ownership effect on carbon disclosure. This also supports the broader conclusion that ownership mechanisms should not be treated as automatically effective proxies for environmental accountability.

IO produces the most notable governance results because the coefficient is significant but negative. This finding does not imply that institutional investors oppose environmental responsibility. Rather, within this sample and model, higher aggregate institutional ownership is associated with a narrower CED after controlling for other variables. One interpretation is that institutional owners in capital-intensive energy firms may prioritize financial resilience, asset productivity, or transition financing and obtain information through private monitoring channels rather than demanding broader public disclosure. Another possibility is that aggregate institutional ownership conceals heterogeneity among domestic, foreign, long-term, and short-horizon institutions in the US. Existing research confirms that ownership type can matter differently across disclosure settings (Febrianto et al., 2022; Fuadah et al., 2022; Putri et al., 2022). Consequently, this result should be treated as evidence against the simple positive monitoring hypothesis, not as proof of a universal negative institutional ownership effect. International literature helps explain why the direction may differ from the theoretical prediction. The systematic review by Velte et al. (2020) shows that the governance-related determinants of carbon disclosure are heterogeneous and depend on how governance quality is defined. Lu and Wang (2021) similarly emphasized that legal, cultural, and institutional conditions shape the relationship between governance and environmental disclosure. Bui et al. (2020) find that climate governance is relevant to disclosure and environmental performance; however, their emphasis on climate-specific governance suggests that a broad ownership percentage may not capture the channel through which investors influence reporting. Kılıç and Kuzey (2019) also link corporate governance to carbon disclosure through broader governance characteristics rather than through ownership measures alone. These comparisons indicate that the negative coefficient may reflect monitoring substitution, differences in investor horizons, or a mismatch between aggregate ownership and active climate engagement. This result could also arise because institutional investors receive detailed information privately, making public disclosure less necessary from the management's perspective. These explanations are plausible mechanisms, not causal conclusions established by the present pooled data. The empirical implication is that future research should separate institutional owner categories, investment horizons, foreign and domestic ownership, common ownership, engagement activity, and sustainability mandates.

The AC size is not significant. This result is theoretically informative because the variable measures quantity rather than capabilities. Most observations have three to five committee members, which gives the predictor a narrow empirical range. A committee of the same size can differ materially in terms of independence, financial expertise, sustainability knowledge, meeting frequency, and authority over non-financial reporting. Simamora et al. (2022) find a positive audit committee effect in another context, while Suherman and Kurniawati (2023) and recent governance research suggest that outcomes depend on the governance characteristics actually measured. International evidence similarly indicates that climate-specific governance processes are more closely connected to carbon transparency than generic board structures (Bui et al., 2020; Kılıç & Kuzey, 2019). Therefore, the insignificant coefficient points to a measurement limitation rather than establishing that audit committees are irrelevant to carbon reporting.

Firm size was not statistically significant in the final model. Larger firms often disclose more information because of their visibility and reporting resources. However, the energy sector sample is already composed of public companies exposed to similar market and sustainability-reporting pressures. Restricted sectoral variation may therefore reduce the incremental explanatory power of

size after environmental performance and governance variables are included in the model. This result is consistent with the mixed evidence in the literature on firm characteristics and carbon disclosure (Suryani & Wijayati, 2019; Setiawan et al., 2022).

Taken together, these results suggest that observable environmental performance is a clearer disclosure signal than the three formal GCG proxies used in this study. This does not diminish the importance of good governance. Instead, it suggests that governance must be measured at a more functional level. Studies on carbon and ESG disclosure increasingly emphasize board independence, climate expertise, sustainability committees, external assurance, institutional owner type, and explicit climate oversight rather than only ownership proportions or committee headcount (Velte et al., 2020; Blesia et al., 2023; Yasa & Sudana, 2025; Aprilia et al., 2026). International evidence reaches a similar conclusion by distinguishing generic governance structures from climate governance capabilities (Kılıç & Kuzey, 2019; Bui et al., 2020; Lu & Wang, 2021). For Indonesian energy companies, the practical implication is to integrate environmental performance with credible governance processes so that carbon disclosure reflects both actual environmental achievement and accountable oversight. For researchers, the implication is to treat ownership and committee size as starting proxies that require refinement, rather than as complete measures of investor monitoring or climate accountability.

The broader Indonesian evidence also illustrates this heterogeneity. Ownership structures, firm characteristics, environmental performance, and governance mechanisms can produce different disclosure outcomes across samples and periods. These differences may reflect variations in industry characteristics, regulatory pressures, stakeholder expectations, reporting practices, and the institutional contexts in which firms operate (Akhsani & Sumarta, 2025; Luthfiani et al., 2026; Nawangsih et al., 2025; Rusdi & Helmayunita, 2023; Sukmawati & Henny, 2024; Wirawan & Setijaningsih, 2022).

The findings are also relevant to the green transition narrative. Disclosure alone cannot substitute for emission reduction, but transparent carbon information allows stakeholders to evaluate whether companies recognize climate risks, measure emissions consistently, report energy use, explain reduction initiatives and assign governance responsibility. Therefore, environmental performance and disclosure should be interpreted as complementary rather than interchangeable dimensions. Research on carbon performance and disclosure likewise cautions that extensive reporting is most informative when it corresponds to genuine performance and governance quality (Bui et al., 2020; Velte et al., 2020).

5. CONCLUSIONS

5.1 Conclusion

This study provides two connected conclusions about carbon emission disclosure by Indonesian energy companies during the 2021-2024 green-transition period. First, environmental performance is the most consistent empirical correlate of CED among the sampled firms. Companies with stronger PROPER performance disclose broader carbon information, which is consistent with the legitimacy mechanism that observable environmental achievements provide firms with credible content to communicate and with the stakeholder mechanism that concrete performance helps meet demands for environmental accountability. Managerial ownership and audit committee size did not show the predicted associations. Institutional ownership is significantly associated with disclosure in the opposite direction from H3; thus, the result rejects the simple positive monitoring expectation for this sample rather than establishing a universal negative effect. The jointly significant model indicates that the explanatory variables provide useful information when considered together, although the result does not mean that every individual mechanism is significant or that the model captures all determinants of CED. Second, the findings refine the theoretical and empirical understanding of governance issues. Formal ownership percentages and committee headcounts do not necessarily represent the quality of climate oversight. Investor type, investment horizon, engagement practices, committee expertise, sustainability responsibilities, and the use of private monitoring channels may determine whether governance improves public carbon transparency. Therefore, this study contributes a context-sensitive comparison between the realized environmental performance and formal

governance structures in a high-visibility, capital-intensive industry. This also demonstrates why statistical significance must be interpreted together with the coefficient direction. For companies, carbon reporting should be linked to verifiable environmental outcomes and substantive climate governance processes. For investors and regulators, disclosure quality should be assessed alongside environmental performance and the credibility of oversight that supports it. Because the analysis applies a Cochrane-Orcutt correction to pooled firm-year data, these conclusions should be understood as sample-specific associations and should be tested using panel estimators in future research.

5.2 Research Limitations

However, several limitations constrain this interpretation. First, the sample contains only 19 listed energy companies observed for four years; therefore, the findings should not be generalized to other sectors or unlisted firms. Second, the CED is based on an 18-item dichotomous content analysis index. This approach captures disclosure breadth but gives equal weight to simple narrative statements and more substantive quantitative disclosures and does not independently verify the accuracy of reported emissions. Third, PROPER is an ordinal environmental performance proxy and does not directly measure firm-level carbon intensity or absolute emission reduction. Fourth, managerial ownership, institutional ownership, and audit committees are measured in aggregate form; the model does not distinguish between institutional investor types, managerial control thresholds, audit committee independence, expertise, meetings, or sustainability responsibilities. Fifth, the data have a firm-year structure, but the source study estimates multiple linear regressions with a Cochrane-Orcutt correction rather than fixed-effects, random-effects, or other panel estimators. The correction addresses the detected serial correlation within the source analytical procedure, but does not explicitly model unobserved firm heterogeneity. Finally, the short 2021-2024 window overlaps a rapidly changing sustainability-reporting and energy-transition environment; therefore, relationships may evolve as disclosure requirements and investor expectations mature.

5.3 Suggestions and Directions for Future Research

Future research should extend the observation period, broaden sector coverage, and compare high-carbon industries to determine whether the environmental performance effect is sector-specific. Panel estimators should be used to separate within-firm and between-firm variations and to test robustness to firm and year effects. Carbon transparency should also be measured beyond a binary checklist by distinguishing quantitative emissions, Scope 1-3 coverage, target credibility, external assurance, transition plans, and year-to-year consistency. Governance variables should be refined to include institutional investor categories, foreign ownership, ownership concentration, audit committee independence and expertise, meeting frequency, sustainability committees, board climate competence, and explicit carbon oversight. Future models can incorporate green investment, media exposure, profitability, leverage, carbon performance, ESG ratings, and regulatory pressure. A particularly useful extension would be to test whether governance moderates the relationship between actual carbon performance and disclosure quality, rather than assuming that more disclosure necessarily means better environmental outcomes. Replication with externally verified emissions data would also help distinguish substantie transparency from symbolic reporting in the future.

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AUTHOR CONTRIBUTIONS

LAZ conducted the source thesis research and the empirical analysis. EY served as a contributing author and participated in manuscript drafting and critical review. UNA supervised the study and contributed to the manuscript review and finalization. All authors have reviewed and approved the final version of this manuscript.

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